

TOWARDS THE DEVELOPMENT OF SUSTAINABLE ALTERNATIVES FOR THE CONTROL OF APPLE REPLANT DISEASE IN WASHINGTON (?).

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Due to its uncertain etiology, the control of apple replant disease has primarily been dependent upon the use of biologically broad-spectrum pre-plant soil sterilants such as methyl bromide. Formulation of alternative measures that approach the levels of disease control achieved with soil fumigants has awaited a clearer understanding of the biotic and abiotic elements which contribute to the disease. As an initial step in the development of biologically sustainable disease control alternatives, a systematic examination of the etiology of apple replant disease was conducted in Washington state (Mazzola 1997, 1998a). In these studies, it was demonstrated that a fungal complex, composed of species belonging to the genera *Cylindrocarpon*, *Phytophthora*, *Pythium*, and *Rhizoctonia*, is the dominant cause of apple replant disease in Washington. Surprisingly, composition of the pathogen complex was consistent across the study sites, though the relative dominance of individual components varied among orchards. It was also shown that, in contrast to previous studies conducted in other geographic regions, the lesion nematode (*Pratylenchus* spp.) generally is present in low populations and has a limited or no role in disease development.

Based on results from these and other studies (Mazzola 1998b), biological, cultural and narrow-spectrum chemical controls were selected which target various components of the causal fungal complex and which operate via differing mechanisms. However, the intent of these studies is to formulate a systems approach to the management of replant disease, thus an emphasis has been placed on utilizing the biological and physical potential of the growing system to suppress disease development.

In preliminary greenhouse trials, the biological agents *Pseudomonas fluorescens* 4A8 and *Pseudomonas putida* 2C8, and the fungicides metalaxyl, difenconazole, and fludioxinil were evaluated for the ability to enhance growth of apple in replant soils from the WVC and GC orchards located in Wenatchee and Manson, WA, respectively. In addition, due to the presence of significant populations of *Pratylenchus penetrans*, the nematicide fenamiphos was evaluated in GC orchard soil. With the exception of fludioxinil, all treatments significantly enhanced growth of apple in WVC orchard soil, but effective fungicide treatments performed significantly better than the biological agents tested (Table 1). At the GC orchard, all treatments that selectively suppressed *Rhizoctonia* spp., including strain 2C8, fludioxinil and difenconazole, significantly improved the growth of apple. Efficacy, or lack thereof, correlated well with specific activity of the control measure and the relative importance of elements of the pathogen complex in the two soils. For example, fludioxinil enhanced growth of apple in GC soil, where *R. solani* AG 5 dominated, but not WVC soil where all components of the complex contributed to disease development. Application of fludioxinil to WVC soil resulted in an increase of nearly 100% and 50%, respectively, in the recovery of *Pythium* and *Cylindrocarpon* spp. from the roots of apple.

Short-term cover cropping and fallow periods are being examined for the ability to reduce the inoculum potential of the pathogen complex inciting apple replant disease. Crop species that directly reduce pathogen activity through their biofumigant properties, as well as those that do so indirectly by enhancing populations of resident antagonists, are

being evaluated. Wheat was selected for its utility as a cover crop based on the observation that apple supports a fluorescent pseudomonad population that in general lacks antifungal activity, while the majority of isolates from the rhizosphere of wheat inhibited in vitro growth of the fungal complex causing replant disease. In addition, Rhizoctonia root rot of apple could not be induced when apple seedlings were grown in wheat field soil artificially infested with *R. solani* AG 5, but severe disease was incited when the same trials were conducted in apple orchard soil. In greenhouse trials, repeated cropping of replant orchard soils with wheat resulted in significant changes in the composition of fluorescent pseudomonad populations. Of three wheat cultivars examined, cropping soils to the soft-white winter wheat 'Eltan' consistently resulted in an increase in the relative population of *Pseudomonas putida* and a corresponding decrease in the population of *Pseudomonas fluorescens* btp C. Apple seedlings planted in this wheat cultivated soil exhibited enhanced growth relative to that obtained in untreated orchard soil.

Based on these initial studies, specific treatments were selected for evaluation in field trials conducted at the WVC orchard and the CV orchard located near E. Wenatchee, WA. Strain 2C8 significantly improved radial growth of 'Gala' on M26 rootstock at the WVC orchard, but had no apparent effect on tree growth at the CV orchard. Soil excavation in the fall of 1997 prior to planting in May 1998 at the CV orchard improved terminal shoot growth of apple, and growth was equivalent to that obtained with methyl bromide fumigation (Table 2). Trees planted in the old orchard aisles exhibited an increase in tree diameter relative to controls planted in the old orchard rows. Cover crop trials have been established at the CV and WVC orchards, in addition to a commercial orchard near Manson, WA, and these trials will be planted to apple in 1999. Future studies will explore the integration of pre-plant measures such as cover crops or soil disturbance, with chemical or biological agents identified in the currently ongoing field trials.

References

- Mazzola, M. 1997. Identification and pathogenicity of *Rhizoctonia* spp. isolated from apple roots and orchard soils. *Phytopathology* 87:582-587.
- Mazzola, M. 1998a. Elucidation of the microbial complex having a causal role in the development of apple replant disease in Washington. *Phytopathology* 88:930-938.
- Mazzola, M. 1998b. Changes in microbial community structure in response to apple roots: Impact on disease-suppressive potential and development of apple replant disease. In, *Proceedings 7th International Congress of Plant Pathology*, Edinburgh, Scotland, August 9-16, 1998. Abstract 2.7.2

Table 1. Effect of biological and chemical treatments on terminal shoot growth (cm) of ‘Gala’ apple in replant soils from the WVC and GC orchards in Washington state.

Treatment	WVC ^a	GC
Control	4.6	22.9
95 C pasteurization	24.8	33.5
<i>Pseudomonas fluorescens</i> 4A8	10.3	23.6
<i>Pseudomonas putida</i> 2C8	14.5	31.8
metalaxyl	21.6	21.8
difenconazole	20.8	34.2
fludioxinil	9.4	32.8
fenamiphos	.b	24.3
difenconazole +metalaxyl	21.6	-
difenconazole+fludioxinil+metalaxyl	22.2	-
difenconazole+fenamiphos+fludioxinil	-	29.6
LSD ($P=0.05$)	4.8	6.2

^aStudies were conducted in the greenhouse in soils collected from the WVC orchard in E. Wenatchee, WA and the GC orchard in Manson, WA.

^bTreatment not assessed.

Table 2. Effect of biological, cultural and chemical treatments on terminal shoot length and diameter of ‘Gala’ on M26 rootstock in a field trial planted in 1998 at the CV orchard near E. Wenatchee, WA.

Treatment	Shoot length (cm)	Increase in tree dia. (mm)
Control	44.0	2.4
Mbr fumigation	58.4	4.1
Soil excavation	60.1	3.8
Interplant (aisle)	42.7	3.5
<i>Pseudomonas putida</i> 2C8	43.6	2.8
<i>Pseudomonas aureofaciens</i> IBX	36.7	2.8
RootShield (<i>T. harzianum</i>)	33.5	2.1
difenconazole	43.3	2.6
flutolanil	38.8	2.3
flutolanil+metalaxyl	45.9	2.1
humic acid	39.6	2.3
LSD ($P=0.05$)	10.1	0.65